CBSE Test Paper 02
Chapter 15 Waves

1. A man is watching two trains one leaving and other approaching with equal velocities of 4 m/s. If they sound their whistles each of natural frequency 240 Hz, the number of beats heard per sec by the man will be (velocity of sound in air 320 m/s) **1**
   a. 6
   b. 12
   c. None of these
   d. 4
2. Matter waves are useful in **1**
   a. explaining gravitational phenomenon
   b. explaining astronomical phenomenon
   c. explaining quantum mechanical phenomenon
   d. explaining tidal wave phenomenon
3. A fork of unknown frequency when sounded with another fork of frequency 256 Hz produces 4 beats/sec. The first fork is loaded with wax. It again produces 4 beats/sec. When sounded together with the fork of 256 Hz frequency, then the frequency of first tuning fork is **1**
   a. 260Hz
   b. 252 or 260 Hz
   c. 258 Hz
   d. 252 Hz
4. A stretched string fixed at both ends has n nodes then the length of string in terms of wavelength is **1**
   a. (n - 1) $\frac{\lambda}{2}$
   b. (n + 1) $\frac{\lambda}{2}$
   c. n $\frac{\lambda}{2}$

d. (2n - 1) $\frac{\lambda}{2}$

5. If y(x, t) = a sin (kx + ωt + φ) represents a wave function then 'k' is **1**

   a. the period
   b. the angular wave number
   c. the frequency
   d. the phase

6. Does a vibrating source always produce sound? **1**

7. Why are all stringed instruments provided with hollow boxes? **1**

8. Velocity of sound increases on a cloudy day. Why? **1**

9. What are transverse waves? Give examples too. **2**

10. The shortest wavelength of the ultrasonic waves that a bat emits is approximately 3.32 mm at 0^{0} C. What is the frequency of these waves? Speed of sound in air at 0 ^{0}C = 332 ms^{-1}. **2**

11. A guitar string is 100 cm long and has a fundamental frequency of 125 Hz. Where should it be pressed to produce a fundamental frequency of 200 Hz ? **2**

12. State important characteristics of a mechanical wave motion. **3**

13. An ambulance is travelling down a highway at 34.5 m/s. The ambulance having siren emits sound of frequency 380 Hz. If a passenger in a car travelling with the speed of 26.4 m/s in the opposite direction approaches the ambulance then find the frequency heard by that passenger. Take the speed of sound in air is 343 m/s. **3**

14. If string wires of same material of length l and 2l vibrate with frequencies 100HZ and 150 HZ. Find the ratio of their frequencies? **3**

15. Show that when a string fixed at its two ends vibrates in 1 loop, 2 loops, 3 loops and 4 loops, the frequencies are in the ratio 1 : 2 : 3 : 4. **5**

Answer

1. a. 6

   Explanation: For source moving towards observer and
   Observer is at rest
   $f_1 = \frac{v}{v-u} \times f$
   $f_1 = \frac{320}{320-4} \times 240$
   f_1 = 243.03 Hz

   For source moving away from observer
   $f_2 = \frac{v}{v+u} \times f$
   $f_2 = \frac{320}{320+4} \times 240$
   f_2 = 237.03 Hz

   No. Of beats n = f_1 - f_2

   n = 243.03 - 237.03

   n = 6

2. c. explaining quantum mechanical phenomenon

   Explanation: Matter waves are also termed as De Broglie waves because they were initially introduced by him. All matters behave like a wave (during motion) and in there propagation there is action of forces due to collision between the particles, some time torque also exists, hence all the matters waves were consider to be a helpful part for understanding quantum.

3. a. 260Hz

   Explanation: An unknown tuning fork i is producing 4 beats/sec with the fork of frequency 256Hz. This means that their frequencies differ by 4. The unknown fork might have frequency either 252 Hz or 260 Hz.
   On the application of wax, the number of beats remains to 4 per second which means they differ only by 4 and it is only possible when the unknown fork has a greater frequency.
   Hence the unknown tuning fork have frequency of 260Hz.

4. c. n $\frac{\lambda}{2}$
Explanation: To satisfy boundary conditions
kL=nπ
$\frac{2\pi L}{\lambda} = n\pi$
$L = \frac{n\lambda}{2}$
Where n can be 1,2,3........

5. b. the angular wave number
Explanation: In the equation
y(x, t) = a sin (kx + ωt + φ)
the term with distance travelled 'x' is called angular wave number or propagation constant
Hence k is the angular wave number.

6. A vibrating source produces sound only when it vibrates in a medium and generates frequency within the audible range i.e. from 20 Hz to 20 kHz.

7. The stringed instruments are provided with a hollow box called sound box. When the strings are set into vibration, forced vibrations are produced in the sound box. Since sound box has a large area, it sets a large volume of air into vibration. This produces a loud sound of the same frequency of that of the string.

8. Since on a cloudy day, the air is wet i.e. it contains a lot of moisture, As a result of which the density of air is less and since velocity is inversely proportional to density, hence velocity increases.

9. Transverse waves are the waves in which the medium particles vibrate to and fro about their mean positions at right angles to the direction of wave propagation. Transverse waves travel in the form of crests and troughs. One crest and the adjoining trough constitute one wave.
A simple example is given by the waves that can be created on a horizontal length of string by anchoring one end and moving the other end up and down. Another example is the waves that are created on the membrane of a drum. The waves propagate in directions that are parallel to the membrane plane, but the membrane itself gets displaced up and down, perpendicular to that plane. Light is another

example of a transverse wave, where the oscillations are the electric and magnetic fields, which point at right angles to the ideal light rays that describe the direction of propagation.

10. Here velocity of sound, v = 332 ms^{-1} and shortest wavelength λ_{min} = 3.32 mm = 3.32 $\times$ 10^{-3} m.

$\therefore$ Maximum frequency of waves produced by bat is,

f = $\frac{v}{\lambda_{\min}}$

= $\frac{332\mathrm{ms}^{-1}}{3.32\times10^{-3}}$ = 10^5 Hz.

11. The fundamental frequency of a stretched string fixed at both end is

$\nu = \frac{v}{2L}$, v being velocity of sound

$\Rightarrow \nu = \frac{1}{2L}\sqrt{\frac{T}{\mu}}\left[\because v = \sqrt{\frac{T}{\mu}}\right]$, T and μ are tension and mass per unit length respectively

As T and μ are fixed

$\frac{\nu_1}{\nu_2} = \frac{L_2}{L_1} \Rightarrow L_2 = \frac{\nu_1}{\nu_2}L_1$

$\Rightarrow L_2 = \frac{125\mathrm{Hz}}{200\mathrm{Hz}} \times 100 = \frac{125}{2}$ = 62.5 cm

12. Important characteristics of mechanical wave motion are as given below :

    i. Wave motion is a form of disturbance which travels from one point to another through a medium.
    ii. The medium particles, through which the disturbance propagates, vibrate to and fro about their mean positions harmonically and suffer no permanent displacement.
    iii. Wave motion is both periodic in space and periodic in time. Hence it is a doubly periodic phenomenon.
    iv. The motion of each particle begins a little later than that of its predecessor. In other words, there is always a constant phase difference between any two neighbouring particles. The wave always advances in that direction in which it meets particles with decreasing phase.
    v. The velocity of the wave is the rate at which the disturbance spreads in the medium. The wave velocity is different from particle velocity.The velocity of a wave is constant in a given medium , whereas the velocity of the particles changes,

being maximum in the mean position.

vi. For wave motion, a medium must be elastic and must possess mass. Moreover, frictional resistance due to the medium should be negligible.

vii. Waves travels from one medium to another , the wave speed and wavelength change but the frequency remains the same because the frequency is determined by the source.

13. Given, Speed of sound in air, v = 343 m/s
Speed of the observer (i.e. passenger in the car)
v_o = 26.4 m/s
Speed of the source (i.e. Ambulance in this case)
v_s = 34.5 m/s
Emitting frequency from the ambulance
ν_0 = 380 Hz
Then the frequency heard by the passenger, $\nu = \nu_0 \left(\frac{v+v_0}{v-v_s}\right)$ [applying the formula of Doppler effect]
$\Rightarrow \nu = 380 \times \left(\frac{343+26.4}{343-34.5}\right) = 380 \times 1.197 = 455$ Hz
This is the required frequency heard by the passenger.

14. Since frequency f of a vibrating string of mass m and Tension T , length l is given by:
$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$
Let for first case, f_1 = 100HZ ; l_1 = l ; T_1 = Initial Tension
For second case, f_2 = 150HZ ; l_2 = 2l ; T_2 = Final Tension
So, frequency for length l is
$f_1 = \frac{1}{2l_1}\sqrt{\frac{T_1}{m}}$
$\Rightarrow f_1 = \frac{1}{2l}\sqrt{\frac{T_1}{m}}$
$\Rightarrow 100 = \frac{1}{2l}\sqrt{\frac{T_1}{m}} \rightarrow (1)$
Now frequency for length 2l is
$\Rightarrow f_2 = \frac{1}{2l_2}\sqrt{\frac{T_2}{m}}$
$\Rightarrow 150 = \frac{1}{2\times 2l}\sqrt{\frac{T_2}{m}} \rightarrow (2)$
Divide equation 1) by equation 2)

$$\Rightarrow \frac{100}{150} = \frac{\frac{1}{21}\sqrt{\frac{T_1}{m}}}{\frac{1}{4l}\sqrt{\frac{T_2}{m}}}$$

$$\Rightarrow \frac{100}{150} = \frac{1}{2}\sqrt{\frac{T_1 \times m \times 4}{m \times T_1}}$$

$$\Rightarrow \frac{10}{15} = 2\sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{2}{3} = 2\sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{2}{3 \times 2} = \sqrt{\frac{T_1}{T_2}}$$

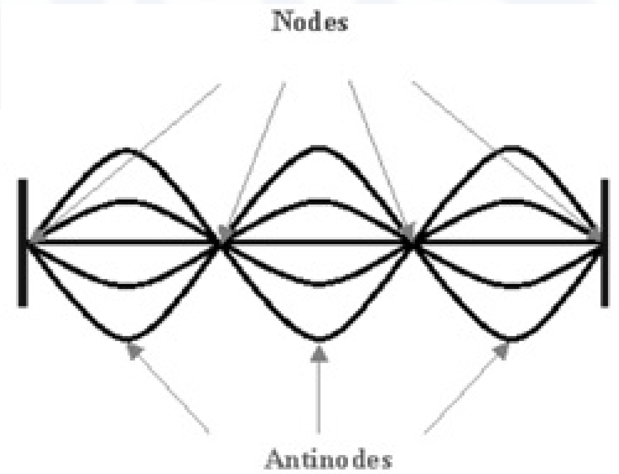
$$\Rightarrow \frac{1}{3} = \sqrt{\frac{T_1}{T_2}}$$

Squaring both sides we get,

$$\Rightarrow \frac{1}{9} = \frac{T_1}{T_2}$$

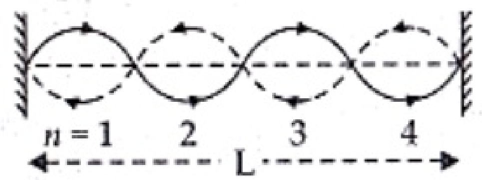
Hence, the ratio of tensions is1: 9

15. Stationary waves are produced by the superposition of two waves of same frequency and amplitude travelling with same velocity in opposite directions. Due to the constructive interference, these waves produce certain fixed points along the medium which undergo zero displacement. Nodes are known as the points of no displacement. Midway between every nodes are regions of maximum displacement. These points are called antinodes.



Let n be the number of loops in the string and the length of each loop is $\frac{\lambda}{2}$.

$\therefore L = \frac{n\lambda}{2}$ or $\lambda = \frac{2L}{n}$



Now, speed of wave is,

$v = \nu\lambda$ and $\lambda = \frac{v}{\nu}$

So, $\frac{v}{\nu} = \frac{2L}{n}$

Thus, $\nu = \frac{n}{2L}v$

For n = 1, $\nu_1 = \frac{v}{2L} = \nu_0$

If n = 2, then $\nu_2 = \frac{2v}{2L} = 2\nu_0$

If n = 3, then $\nu_3 = \frac{3v}{2L} = 3\nu_0$

If n = 4, then $\nu_4 = \frac{4v}{2L} = 4\nu_0$

$\therefore \nu_1 : \nu_2 : \nu_3 : \nu_4 = 1 : 2 : 3 : 4$

Hence proved.